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DESCRIPTION

Air Supply Device

Technical Field

The present invention relates to an air supply device that is used as, for example, a supercharger for an engine or an air compressor for a fuel cell.

Background Art

In fluid machinery, sliding portions are generally lubricated with an oil in order to prevent seizing or abnormal wear or abrasion. Accordingly, a fluid discharged from the fluid machinery is somewhat mixed with the oil, and it is extremely difficult to remove the oil from the fluid. In view of this, the use of bearings such as grease-filled ball bearings for the sliding portions has been suggested to perform lubrication only within the bearings for supply of a clean fluid (see, for example, Patent Document 1).

・Patent Document 1: Japanese Laid-Open Utility Model Publication No. 62-59788 (pages 9 and 10, Fig. 1)

The use of the grease-filled bearings is not limited to the fluid machinery, and they are generally used in various fields including the field of automotive vehicles, the field of medical machinery and the like. Such grease-filled bearings have two sealing materials disposed on respective sides thereof that prevent grease from being mixed with dust or moisture in the atmosphere. If the grease-filled bearing merely supports a rotational motion, the grease filled inside would never leak outside the bearing.

However, in the case of a scroll fluid machine in which an orbiting scroll undergoes an orbiting motion relative to a stationary scroll to compress a fluid, the orbiting motion of the orbiting scroll is performed with a certain fixed radius and, hence, a centrifugal force acts on bearings mounted on the orbiting scroll.

ATTACHMENT "B"

Because of this, such a phenomenon occurs that the grease filled inside oozes out from an end surface of the sealing material and scatters outside.

Further, of a plurality of bearings located inside a compressor, some are subject to a pressure difference generated between opposite sides thereof, which sometimes promotes leakage of the grease. If the leakage of the grease occurs, not only the reliability of the bearing reduces, but there is also a good chance that the fluid discharged is mixed with the grease.

The present invention has been developed to overcome the above-described disadvantages.

It is accordingly an objective of the present invention to provide an air supply device capable of prolonging the life of bearings mounted therein, enhancing the reliability of the bearings, and supplying clean air without causing any leakage of grease from the bearings.

Disclosure of the Invention

In accomplishing the above objective, the air supply device according to the present invention includes a compression mechanism section having a stationary scroll and an orbiting scroll held in engagement with each other, and a drive section for driving the compression mechanism section, wherein the compression mechanism section and the drive section have a common shaft, by way of which the orbiting scroll is caused to undergo an orbiting motion with respect to the stationary scroll to thereby compress air sucked into the compression mechanism section. The air supply device also includes a plurality of rotation constraint members for preventing rotation of the orbiting scroll about its own axis, but allowing the orbiting scroll to orbit relative to the stationary scroll, a plurality of first grease-filled bearings for rotatably supporting the common shaft, a plurality of second grease-filled bearings for rotatably supporting the orbiting scroll, and a plurality of third grease-filled bearings for rotatably supporting each of the rotation constraint members. Each of the second bearings has an outer ring, an inner ring,

a plurality of rolling elements interposed between the outer and inner rings, and two sealing materials disposed on respective sides of the plurality of rolling elements. Each of the sealing materials has an inner end held in contact with the inner ring and an outer end held in contact with the outer ring.

According to the present invention, because the bearings employed in the air supply device are of the grease-filled type, no oil is needed for lubrication of the sliding portions and, hence, the air discharged from the air supply device is mixed with no oil mist, making it possible to supply clean air. Further, because the inner ring and the outer ring of the bearings are assuredly sealed by the sealing materials, even if a centrifugal force acts on the grease inside the bearings upon an orbiting motion of the orbiting scroll with a fixed radius, scattering of the grease is avoided, making it possible to prolong the life of the bearings and enhance the reliability of the bearings.

Where each of the sealing materials for the second bearings has an inner bent portion that has been bent towards a low-pressure side from a high-pressure side, and the inner bent portion is held in contact with the inner ring, the compressed high-pressure air is further prevented from leaking into a suction chamber via a central portion of the orbiting scroll. As to the low-pressure side, even if the temperature or pressure inside the bearings increases during operation, leakage of the grease from the inside to the outside is avoided.

If one of acrylic rubber, Teflon rubber and fluoro rubber is used for the sealing materials, hardening that may be caused by heat is reduce, enabling a high-speed operation and an increase in the amount of supply air. In addition, the amount of leakage of the grease can be further suppressed.

Each of the rotation constraint members may include a crankpin having an insertion portion inserted into an associated one of the third bearings, wherein the insertion portion has a groove defined in a surface thereof so as to extend parallel to a longitudinal axis thereof. Alternatively, the orbiting scroll or the

casing may have a plurality of recesses defined therein into each of which one of the third bearings is press fitted, wherein each of the plurality of recesses has a groove defined in an inner surface thereof so as to extend parallel to a longitudinal axis of an associated one of the rotation constraint members. In such case, the groove comes to act as an air escape passageway when the rotation constraint members are assembled with the orbiting scroll, thereby causing no closed spaces during assemblage and facilitating the assemblage of the rotation constraint members.

If the width and the depth of the groove are both set to a value ranging from 0.1mm to 1.0mm, the insertion portion of the crankpin or a recess into which the insertion portion is engaged is not deformed by a load applied during operation, and at the same time the groove can satisfactorily achieve its function as an air escape groove.

Brief Description of the Drawings

Fig. 1 is a sectional view taken along a longitudinal axis of an air supply device according to the present invention.

Fig. 2 is a sectional view taken along a longitudinal axis of an orbiting scroll mounted in the air supply device of Fig. 1.

Fig. 3 is a sectional view taken along an axial center of one of a plurality of bearings mounted in the air supply device of Fig. 1.

Fig. 4 is a sectional view taken along an axial center of a modified form of the bearing of Fig. 3.

Fig. 5A is a front view of a crankpin forming a rotation constraint member mounted in the air supply device of Fig. 1.

Fig. 5B is a side view of the crankpin of Fig. 5A.

Fig. 6 is a rear view of the orbiting scroll of Fig. 2.

Detailed Description of the Preferred Embodiments

A preferred embodiment of the present invention is discussed

hereinafter with reference to the drawings.

Fig. 1 is a sectional view taken along a longitudinal axis of an air supply device according to the present invention, particularly depicting a general construction of the air supply device.

As shown in Fig. 1, the air supply device according to the present invention includes a drive section (motor section) 10, a compression mechanism section 20, and a discharge casing section 50.

The drive section 10 includes a cylindrical motor frame 11, a stator 12 secured to an inner surface of the motor frame 11, a rotor 13 secured to a motor shaft 41 to rotate within the stator 12, and a motor bearing plate 14 for closing one end of the motor frame 11. The motor bearing plate 14 includes a first bearing 71 secured thereto at a central portion thereof, which in turn rotatably supports one end of the motor shaft 41.

The compression mechanism section 20 includes an orbiting scroll 21 operated by the action of an orbiting shaft 42, a stationary scroll 22 for forming a plurality of compression chambers 26 between it and the orbiting scroll 21, and a plurality of rotation constraint members 23 operable to orbit the orbiting scroll 21. The orbiting scroll 21 has an orbiting scroll wrap 21A unitarily formed with an end plate and having a predetermined height, while the stationary scroll 22 has a stationary scroll wrap 22A unitarily formed with an end plate and having a predetermined height. The orbiting scroll wrap 21A and the stationary scroll wrap 22A are positioned so as to engage with each other.

A clearance is provided between a side surface of the orbiting scroll wrap 21A and that of the stationary scroll wrap 22A so that they may not be brought into contact with each other. The orbiting scroll wrap 21A and the stationary scroll wrap 22A are each provided at an end surface thereof with a tip seal 21B or 22B, respectively. Accordingly, the end surface of the orbiting scroll wrap 21A is held in contact with the stationary scroll 22 by way of the tip seal 21B, while the end surface

of the stationary scroll wrap 22A is held in contact with the orbiting scroll 21 by way of the tip seal 22B.

The compression mechanism section 20 includes a casing 31 that is made up of a disc-shaped partition plate 31A for sealingly partitioning the other end of the motor frame 11 and one end of the compression mechanism section 20 from each other, and a cylindrical member 31B for covering the components parts accommodated in the casing 31. The partition plate 31A has a through-hole 33 defined therein at a central portion thereof, in which a second bearing 72 is received to rotatably support the other end of the motor shaft 41. The cylindrical member 31B has a suction port 24 defined therein, through which air is introduced into the compression mechanism section 20.

The discharge casing section 50 includes a discharge casing 51 that in turn includes a disc-shaped plate 51A and a cylindrical member 51B secured to or otherwise integrally formed with an outer peripheral portion of the plate 51A. The plate 51A is provided with a third bearing 73 secured thereto at a central portion thereof. An adapter 48 is secured to the other end of the orbiting shaft 42 and rotatably supported by the third bearing 73 with the center of the adapter 48 held in alignment with a rotation center of the motor shaft 41. The plate 51A has a discharge port 25 defined therein, through which air compressed by the compression mechanism section 20 is discharged.

The rotation constraint members 23 are operable to prevent the orbiting scroll 21 from rotating about the orbiting shaft 42, but allow the orbiting scroll 21 to orbit around a longitudinal axis of the motor shaft 41. More specifically, each rotation constraint member 23 includes a crankpin 23A interposed between the casing 31 and the orbiting scroll 21, and the crankpin 23A is provided with bearings 23B, 23C that rotatably support opposite ends of the crankpin 23A, respectively. A grease-filled ball bearing is preferably used as the bearings 23B, 23C. A plurality of (for example, three) crankpins 23A are interposed between the partition plate 31A

and the orbiting scroll 21 and equally spaced from the orbiting shaft 42 and also from each other.

A rotary shaft 40 is made up of the motor shaft 41 and the orbiting shaft 42 unitarily formed with each other and both referred to above. The rotary shaft 40 is rotatably supported at one end thereof by the first bearing 71, at an intermediate portion thereof by the second bearing 72, and at the other end thereof by the third bearing 73 via the adapter 48. Because the motor shaft 41 is supported by the first bearing 71 and the second bearing 72 and because the orbiting shaft 42 is supported by the second bearing 72 and the third bearing 73, both the motor shaft 41 and the orbiting shaft 42 are of a construction supported at opposite ends thereof. The rotary shaft 40 is crank-shaped, that is, the orbiting shaft 42 is eccentric with respect to the motor shaft 41.

The orbiting shaft 42 is provided with two bearings 74, 75 mounted thereon, by which the orbiting scroll 21 is rotatably supported. The bearing 74 is located on the root side of the orbiting scroll wrap 21A, while the bearing 75 is located on the distal end side of the orbiting scroll wrap 21A.

The orbiting shaft 42 is also provided with a pre-loading spring 44 interposed between a balance weight 47 and the bearing 75 under the condition in which a compression load is applied thereto. Accordingly, the pre-loading spring 44 presses an inner ring of the bearing 75 towards the drive section 10, and a load applied to the inner ring is transmitted to an outer ring of the bearing 75 via balls, thereby pressing the orbiting scroll 21 towards the drive section 10. The load applied to the orbiting scroll 21 is received by the crankpins 23A to prevent the orbiting scroll 21 from overturning during a low-speed operation, thereby suppressing vibrations.

The orbiting shaft 42 is provided with a shaft seal 45 juxtaposed with the bearing 75 at a location between the bearing 74 and the bearing 75. The shaft seal 45 is intended to prevent the compressed air from leaking to the side of the

bearing 74.

In the air supply device of the above-described construction, where clean air is required, lubrication of the sliding portions is of great importance. The use of an oil is advantageous to the lubrication, but air discharged from the air supply device comes to contain an oil mist. Accordingly, a filter is needed to remove such oil mist. Further, because the oil is gradually discharged, periodical oil feed must be done.

In view of the above, the air supply device according to the present invention employs grease-filled bearings as the first bearing 71, the second bearing 72, the third bearing 73, the bearings 74,75 and the bearings 23B, 23C. The use of such bearings confines the sliding portions to only the inside of the bearings, which is lubricated by the grease, making it possible to supply clean air.

The case where the ball bearings are employed as the bearings referred to above is discussed hereinafter.

Fig. 2 is a sectional view taken along a longitudinal axis of the orbiting scroll 21, and as shown therein, the orbiting scroll 21 is provided with two bearings 74, 75 mounted on the orbiting shaft 42 and a plurality of bearings 23B each constituting the rotation constraint member 23.

Fig. 3 depicts one of the bearings 74, 75, 23B referred to above, and the internal construction of the bearing, generally identified by 80, is explained hereinafter with reference to Fig. 3.

The bearing 80 is internally filled with grease, on which a centrifugal force acts during operation, which in turn acts to render the grease to leak outside the bearing 80. In particular, in applications where a clearance is present between sealing materials 81 mounted on respective sides of a plurality of rolling elements 84 of the bearing 80 and an inner ring 82 or an outer ring 83 of the bearing 80, the grease scatters outside, resulting in a reduction in the life of the bearing 80.

In the practice of the present invention, each sealing material 81

mounted in the bearing 80 has a generally L-shaped section taken along an axial center of the bearing 80 and also has inner and outer ends held in contact with the inner ring 82 and the outer ring 83 of the bearing 80, respectively. When the sealing material 81 is held in contact with the inner ring 82 and the outer ring 83 of the bearing 80, the interior and the exterior of the bearing 80 are partitioned without any gap and, hence, even if a centrifugal force acts on the grease inside the bearing 80, leakage of the grease is avoided.

As can be seen from the general construction of Fig. 1, in the air supply device according to the present invention, compressed high-pressure air is present around the distal end portion of the orbiting scroll 21, while intake air of the atmospheric pressure is present around the end plate of the orbiting scroll 21. The high-pressure air flows towards the discharge casing section 50 and is then discharged outside via the discharge port 25. However, part of the high-pressure air flows towards the end plate from the distal end portion after passing through the central portion of the orbiting scroll 21. In order to prevent leakage of such high-pressure air, the shaft seal 45 is provided inside the orbiting scroll 21 at a central portion thereof. However, the use of the shaft seal 45 generally needs an additional power because the shaft seal 45 is held in strong contact with the orbiting shaft 42.

In the practice of the present invention, as shown in Fig. 4, a sealing material 81A intended for the external pressure may be used as a high-pressure side one of the bearing 80, while a sealing material 81B intended for the internal pressure may be used as a low-pressure side one of the bearing 80.

More specifically, the sealing material 81A facing the high-pressure air has bent portions formed at inner and outer end portions thereof, which bent portions have been bent towards the low-pressure side so that an end of the inner bent portion may be brought into closer contact with the inner ring 82 as the atmospheric pressure increases. On the other hand, the sealing material 81B

facing the low-pressure air has an inner bent portion that has been bent towards the low-pressure side, contrary to an outer bent portion, so that an end of the inner bent portion may be brought into closer contact with the inner ring 82 as the internal pressure of the bearing 80 increases.

Because this construction plays a role of the shaft seal 45, the shaft seal 45 as shown in Fig. 1 can be removed to eliminate the additional power, making it possible to increase the efficiency. Also, the sealing properties increase with an increase in pressure and, hence, leakage of the grease within the bearing can be considerably reduced.

When the sealing material 81 is positively brought into contact with the inner ring 82 to enhance the sealing properties, heat is inevitably generated, which in turn reduces the life of the sealing material 81. Because the sealing material 81 becomes hard depending on the temperature, it is important to select rubber having a high heat resistance. Accordingly, acrylic rubber, Teflon rubber or fluoro rubber is preferably used for the sealing material 81. Although the heat resistance increases in the order of acrylic rubber, Teflon rubber and fluoro rubber, it is preferred that the maximum speed be set as one standard for selection.

In applications where all the seals mounted in the orbiting scroll 21 are of the contact type, a difficulty is encountered in assembling the rotation constraint member 23. That is, as shown in Fig. 1, the bearing 23B forming the rotation constraint member 23 is press fitted into a recess formed in a rear surface of the end plate of the orbiting scroll 21, while the bearing 23C similarly forming the rotation constraint member 23 is press fitted into a recess formed in the partition plate 31A and, hence, a rear surface of each bearing 23B, 23C does not communicate with the outside. If the contact type bearing is employed in the air supply device according to the present invention, air is confined to the inside when the crankpin 23A is engaged in the bearing, and an escape port is accordingly needed.

In the practice of the present invention, as shown in Figs. 5A and 5B, the crankpin 23A has two shafts formed on respective sides thereof for insertion into respective bearings, and each shaft has a groove 23L defined in a surface thereof so as to extend parallel to a longitudinal axis thereof. By this construction, when the shaft of the crankpin 23A is inserted into the associate bearing, the air confined by these members is discharged outside through the groove 23L, thus facilitating assemblage of the rotation constraint member 23. Also, because a space delimited by the shaft of the crankpin 23A and the bearing communicates always with outside air, and the pressure in the former and the pressure of the latter are equalized, even if a temperature change occurs upon operation or stop of the air supply device, a pressure change of the air confined by the bearing 23B and the crankpin 23A is suppressed.

In place of the air escape groove 23L formed in the shaft (insertion portion) of the crankpin 23A, an engagement recess 21H formed in the end plate of the orbiting scroll 21 for insertion of the bearing 23B thereinto may have a groove 21L formed in an inner surface thereof so as to extend parallel to the longitudinal axis of the shaft of the crankpin 23A, as shown in Fig. 6, or an engagement recess formed in the casing 31 (partition plate 31A) may similarly have a groove formed in an inner surface thereof so as to extend parallel to the longitudinal axis of the shaft of the crankpin 23A. By this construction, the air so confined is discharged outside through the groove 21L, thus facilitating assemblage of the rotation constraint member 23.

It is preferred that the air escape groove 21L, 23L has a width and a depth both in the range of 0.1mm to 1.0mm. If the groove is too large (if the width or depth of the groove exceeds 1.0mm), there is a possibility that the crankpin 23A, the engaging portion 21H of the orbiting scroll 21, or the engaging portion of the casing 31 is reduced in strength and can not withstand the load during operation, though such a groove is preferable as an air escape one. In contrast, If the groove

is too small (if the width or depth of the groove is less than 0.1mm), there is a possibility that the groove cannot achieve a sufficient function as an air escape one.

Accordingly, by setting the width and depth of the air escape groove 21L, 23L in the range referred to above, it is possible to ensure the strength of the crankpin 23A, the engaging portion 21H of the orbiting scroll 21, or the engaging portion of the casing 31 and the function as the air escape groove at the same time.